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CONSUMPTIVE USE and IRRIGATION WATER REQUIREMENTS

of *Milford Valley, Utah*

Agricultural Research Service
in cooperation with
Utah Agricultural Experiment Station
and Utah State Engineer

UNITED STATES DEPARTMENT OF AGRICULTURE

FOREWORD

Under cooperative agreement, the Utah Agricultural Experiment Station, the Utah State Engineer, and the Division of Irrigation Engineering and Water Conservation of the U. S. Soil Conservation Service, began in 1951 a 4-year investigation of consumptive use and water requirements in the Milford-Minersville area of Utah.

The major responsibility of the Experiment Station in this investigation was a determination of unit values of consumptive use by each of the major crops grown in the area. The procedures followed were similar to those used in a study completed in 1950 in the Vernal and Ferron areas of the Colorado River Basin. Measurement of soil-moisture depletions by the crops were the basis for the unit values established. These studies were correlated with studies from other areas of the West.

The Utah State Engineer, through the U. S. Geological Survey Surface and Ground Water Divisions, supplied streamflow and changes in the ground-water storage data for the valley. The Engineer's office also assisted in mapping and classifying the valley land according to its use and in helping to coordinate the study.

The Division of Irrigation Engineering and Water Conservation of the Soil Conservation Service, now Western Soil and Water Management Research Branch of the Soil and Water Conservation Research Division, Agricultural Research Service, United States Department of Agriculture, was responsible for making the land classification surveys, computing the acreages and applying unit consumptive use values to the land areas, and determining the total valley consumptive use.

It is hoped that this report will add to the general store of knowledge on water use and requirements by agricultural crops and natural vegetation. It is believed that the results will be of immediate value in helping to evaluate the potential water resources of this valley and in determining any further development that can be safely made.

BACKGROUND AND ACKNOWLEDGMENTS

In 1947, the Utah State Engineer entered into formal agreement with the Utah Agricultural Experiment Station and the Division of Irrigation Engineering and Water Conservation, Soil Conservation Service to conduct consumptive use of water studies in the Colorado River Area of Utah. The immediate purpose of these studies was to gather information which would assist in administering the waters of the Upper Colorado River under the terms of the Compact signed in 1948. Under this Compact, the waters were allotted to the various States on a basis of consumptive use. The studies in these areas were completed in 1950. A final report entitled "Consumptive Water Use and Requirements in the Colorado River Area of Utah" was written by W. C. Barrett and C. H. Milligan, published in March 1953 by the Agricultural Experiment Station as Special Report No. 8.

In early 1951, the similar study reported here was begun in the Great Basin near Milford with the same cooperators. Four research fellows from Utah Agricultural Experiment Station--Terrell R. Tovey in 1951, Glen Calder in 1952, Glen L. Steed in 1953, and Charles Busch in 1954--were assigned to this study and carried major responsibilities in conducting field measurements of unit consumptive use of crops. Their conscientious study of the problem has been an essential part of the investigation and the respective Masters theses prepared have assisted materially in the analysis and preparation of this report.

The assistance of the U. S. Geological Survey personnel, both Surface and Ground Water Divisions, has been most helpful and is indeed appreciated.

Dr. Dean K. Fuhriman was project leader for the Experiment Station from 1951 to 1954, and his ideas and direction of the graduate students were important elements in the study.

Dr. O. W. Israelsen of the Experiment Station staff, Mr. George D. Clyde, presently Governor of the State of Utah, Professor Cleve H. Milligan, and others have furnished invaluable suggestions and guidance.

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CONSUMPTIVE USE AND IRRIGATION WATER REQUIREMENTS OF MILFORD VALLEY, UTAH

by

Wayne D. Criddle[1]

INTRODUCTION

Consumptive use has been defined as "The sum of the volumes of water used by vegetative growth of a given area in transpiration and building of plant tissue, and that evaporated from adjacent soil, snow, or intercepted precipitation." It is the amount of water that is changed from a liquid to a gaseous state within an area because of evaporation and/or transpiration.

The consumptive water requirement of a crop grown at one location has been found to be about the same as needed for that same crop at some other location providing the climatic conditions are similar. Also, the source of the water, whether from natural rainfall, ground water, or surface irrigation, has little effect on the amount required to produce a good yield, providing fertility, disease, insects or other factors are not limiting growth and production. Therefore, the more usable rainfall, the less the need for irrigation. And, even though excess irrigation water is applied, actual consumption remains about the same. The excess either returns to the natural water supply of the basin or is consumed on lands other than those originally irrigated. This explains the great amount of "return flow" which occurs in many of our western river systems. As with the Sevier River in central Utah, the flow may be completely diverted for irrigation at various points, but downstream a few miles from each diversion a good size flow will again occur.

For administration of interstate or international river waters, it is sometimes necessary to determine the "virgin flow" of the river. This implies that distinction be made between depletion by virgin vegetation within the basin and changes in depletion resulting from activities of man. It makes the determination of consumptive use by natural vegetation as well as cultivated crops essential. Various mixtures of plants occur under natural conditions, thus requiring that wild vegetation be grouped into different vegetative classes. Consumptive use by each vegetative class must then be known.

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[1] Utah State Engineer, formerly Irrigation Engineer, Western Soil and Water Management Research Branch, Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Department of Agriculture, and Professor of Irrigation and Drainage, Utah Agricultural Experiment Station.

In Utah, the State Engineer is responsible for the general administrative supervision of the waters of the State including measurements, appropriation, apportionment, and distribution thereof in accordance with the respective rights of the appropriators. All of the waters of the State are public whether above or below the ground surface. All rights to the use of water is on a basis of use. Beneficial use is the basis of the measure and the limit to the right.

What constitutes beneficial use is one of the most controversial points in the operation of the entire program of the State Engineer. Certainly in Utah, where waters are so limited, this resource should be used with reasonably high efficiency and not dissipated through misuse and waste. At the same time, the water user rightfully expects a water allotment that is reasonable and just; one that doesn't impose a severe penalty or limitation on the use of the water. Allocations should includ sufficient water to (1) fully meet the consumptive water needs of the crops, (2) give reasonable allowances for conveyance losses from the point of diversion to the point of application, and (3) allow for necessary losses incurred in applying water to the field.

Of the three, consumptive water needs of the crop is best known and most uniform for a particular area. Losses in conveyance and application are widely variable from place to place and between water users. Also, the magnitude of these losses, although closely allied with the physical conditions of the particular site, are influenced greatly by economic considerations and pressures for more water or the possibility of irrigating more land through better use of the water. These latter factors change with time. Needs for development of improved methods of conveying and applying water constantly change. Thus, water allotments made today on a basis of what is now considered beneficial use may need to be changed at some time in the future. Our measure of beneficial use changes. The factor least likely to change materially in the allocation formula is consumptive use.

Prior to 1953, the laws of Utah provided that all costs for adjudications must be assessed against the water users whose rights were being determined. Upon the recommendation of the State Engineer, the 1953 Legislature revised the law. The State General Fund may now be used by the State Engineer to pay adjudication costs. The basis for this action is that (1) the water is public water, (2) about 20 percent of the costs normally would be assessed to public agencies, all of which are uncollectable, (3) there is difficulty in arriving at prorate assessments, and (4) every taxpayer in Utah is a water user and should bear his share of the adjudication costs through general taxation. As might well be expected, this change in the law has given impetus to requests for many new adjudications.

At the present time, adjudication of water rights is underway or pending in various areas of the State. These areas include: (1) The Escalante Valley in Beaver, Iron, and Washington Counties, (2) Bear River in Summit and Rich Counties, (3) Little Bear River in Cache County, (4) Green River in Daggett, Summit, and Uintah Counties, (5) San Rafael River in Emery, Sanpete, and Wayne Counties, (6) Parowan Valley in Iron, Beaver, and Garfield Counties, (7) Utah Lake and Jordan River in Wasatch, Utah, and Salt Lake Counties, and (8) Deep Creek in Uintah Basin.

PURPOSE OF THE STUDY

It is a well known fact that as in all of our arid States there is an inherent shortage of irrigation water in Utah. The Utah Water and Power Board[2/] reports that of the 2,400,000 acres of arable land in the Bonneville Basin, only 864,000 receive any irrigation water with but 338,000 receiving an adequate water supply. This means that approximately two-thirds of the arable land of the Bonneville Basin has no water, and more than one-half of that land under irrigation has only a partial supply. A fact that may not be so well known is that in the Bonneville Basin there are 220,000 acres of arable land that need drainage.

A knowledge of the consumptive use of water by individual areas is important in alleviating both the water shortage and the drainage problems. Lack of information on how much water is needed is one of the reasons for overirrigation. Overirrigation is one of the "manmade factors" influencing drainage needs. If the farmers in each area are furnished reliable information on how much water the various crops use per day, per week, or per month, they can better tell how often to irrigate and how much water to apply each irrigation. Irrigation efficiency could be increased materially, which would, in effect, increase the water supply and decrease the need for drainage.

The above needs for consumptive use data together with the administrative and resource inventory needs for information on water requirements are the major direct purpose of this study. Indirect benefits will come from improving our information on water requirements throughout the West.

[2/] "Water for Utah." Utah Water and Power Board, pp. 113-17, July 1, 1948. (Processed)

DESCRIPTION OF STUDY AREA

The Milford Valley is located at the eastern edge of the great Escalante Desert in the west central portion of Utah (figure 1). The valley runs in a generally south to north direction. It is 10 to 15 miles wide with mountains on either side rising some 5,000 feet above the valley floor. The valley land is relatively smooth and slopes gently toward the north.

The upper end of the valley near Minersville lies at an elevation of about 5,700 feet and the lower end at 5,000 feet. The mean annual temperature is just under 50° F. with maximums and minimums running from - 34° to 104°. The frost-free period is from May 20 to September 23, averaging 126 days. Precipitation averages 8.6 inches at Milford and about 10.9 inches at Minersville. About one-third of the precipitation occurs during the 5-month summer period, May to September. Wide variations in precipitation and freezing dates occur from year to year. Also, there is considerable variation in rainfall within the valley from any one storm. During the spring and early-summer months, there is often considerable wind blowing in a southerly direction. The winds usually start in the forenoon and continue until evening. The nights are generally calm.

The Milford Valley study area includes that land within the valley extending from the stream gaging station near Rockyford Dam above Minersville to the outflow station located on the Beaver River some 4 miles below Milford. It includes all irrigated land plus considerable acreage of nonfarmed land within the general boundaries.

The greater part of the water passing Minersville in the Beaver River quickly finds its way into the sands and gravels of the Lake Bonneville beds. The sediments swept from the canyon were deposited upon the plain to the west of Minersville, forming a delta fan which is nearly flat.

The Beaver River is normally a part of the Sevier Lake drainage. In recent years there has been little water pass the gaging station below Milford. That water which has passed this point has soon percolated into the river bed. In 1952, Beaver River flood waters spread out over a large area known as Beaver Bottom and extended as far as 18 miles north of Milford.

At the present time, the water table is well below the land surface of the valley in all except a few areas in the vicinity of Minersville. Pumping for irrigation has lowered the water table so that many of the shallow wells have to be deepened and pump bowls lowered. However, this condition has not always prevailed.

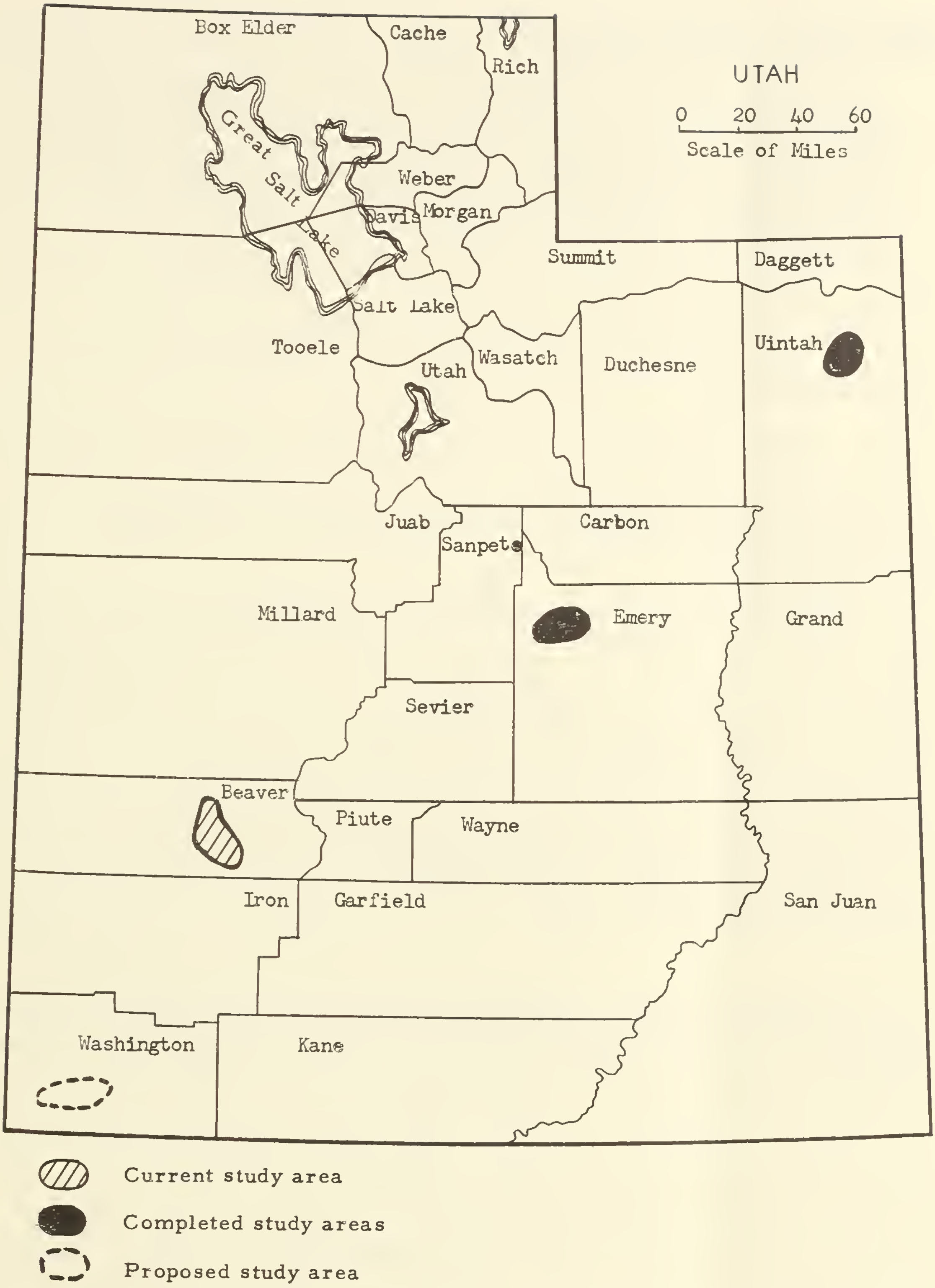

Figure 1. Map Showing Location of Consumptive Use of Water Study Areas.

Willis T. Lee[3] in 1908, writing about underground waters of the Beaver Valley, stated (page 22):

> "In the lower portions of Beaver Basin the surface of the ground water is at or very close to the land surface. During spring and early summer the ground-water level gradually rises, and during late summer and early autumn a considerable part of the low-lands of the valley between Beaver and Adamsville is transformed into a marsh. Many of the roads are rendered impassable and many of the fields useless for tillage or even pasturage. Nearly half of the town of Beaver was thus affected during the summer of 1906. Some of the principal streets were impassable. Water was found flowing freely from dug wells and from cellars, in some cases making houses uninhabitable.
>
> "The lowlands in the vicinity of Milford and to the north, especially in Beaver Bottoms, are similarly affected, although on account of the large area of lowlands and the limited water supply, swampy conditions are not so serious in the Milford region."

The Milford study area contains about 34,000 acres of land of which about 14,500 was the maximum cropped and irrigated during any one year in the 1951 to 1954 period. However, during the investigation considerable change took place in irrigated acreage. In 1951, the irrigated-cropped acreage was only 9,095 acres. Over 6,000 acres were fallowed. In 1953, the fallow land had been decreased to about 2,900 acres but increased to about 3,600 acres in 1954. Also, considerable new land was cleared of brush and put under irrigation each year of the investigation. Several sections of land west of Minersville along the road to Lund were brought under irrigation, as was considerable land above the railroad south and west of Milford. Some sagebrush land within the general boundaries of that classified in 1951 was also plowed up and put under irrigation during 1952 to 1954.

Cropping patterns also changed materially during the 4-year study period. In 1951, alfalfa represented about 55 percent of the irrigated cropped land. Miscellaneous row crops, including potatoes, sugar beets, and beans, were grown on 773 acres or less than 9 percent of the area. In 1953, these miscellaneous crops represented nearly 18 percent of the 14,646 acres of irrigated crop land classified even though alfalfa was still about 51 percent of the total. This major change resulted in the grain acreage being proportionately decreased during 1953.

Over most of the area, the soils are alluvial and rather coarse textured. Except for the lower valley lands toward the town of Milford, the soils are well drained and free of salts. Because of the natural high water table that existed in this lower valley for so many years, some of the lands immediately south and east of Milford are highly saline with some spots of alkali. The soils on these lands are rather fine textured, and internal drainage is slow. Leaching and reclamation of these lands is difficult. With better soils available nearby, and since the irrigable land exceeds the available water supply, it is questionable whether these saline-alkaline soils should be reclaimed, even though the pumping lift might be more favorable here than along the edge of the valley where the new development is taking place.

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[3] "Water Resources of Beaver Valley, Utah" by Willis T. Lee, U. S. Geological Survey Water-Supply Paper No. 217, 57 pages, 1908.

QUALITY OF WATER

As is common with all river systems, Beaver River decreases in quality with distance downstream. However, the salt content does not become sufficiently high to present a serious problem to the type of agriculture practiced in the Milford Valley.[4/]

The quality of the well water varies considerably depending upon the location and depth of the wells. However, all of the irrigation well water tested is at least class three under U. S. Department of Agriculture standards. This should be satisfactory for general use with the relatively permeable soils found in most of the irrigated area.

PREVIOUS INVESTIGATIONS

In 1926-27, White[5/] made a study of the ground-water supplies and their disposition in the Escalante Valley of Utah. Much of his work centered around Milford where an experimental station containing evapo-transpiration tanks and a complete weather station were installed. A summary of these data are given in table 1. He estimated the use of water by alfalfa as about 24.5 inches for the June to October period of 1926 and nearly 31 inches during the April through October period of 1927. Rainfall accounted for over 5 inches of the 1927 use.

In this investigation, White also classified the vegetation on some 31,500 acres of valley land according to its water consuming ability and estimated the rate at which each class consumed water from the ground-water supply. He did not include precipitation as a part of the water consumed.

[4/] "Irrigation Waters of Utah" by J. P. Thorne and D. W. Thorne, Utah Agricultural Experiment Station Bulletin 346, 64 pages, 1951.

[5/] "A Method of Estimating Ground-Water Supplies Based on Discharge by Plants and Evaporation from Soil--Results of Investigations in Escalante Valley, Utah" by Walter N. White, U. S. Geological Survey Water-Supply Paper No. 659, pp. 1-105, 1932.

Table 1.--Summary of use of water by plants grown in tanks in the Milford Area, 1926-27.[1]

Year and month	Rainfall	Depth to water table and evapo-transpiration including rainfall								Evaporation	
		Alfalfa		Salt grass transplanted		Salt grass-sod in place		Greasewood			
		Av. depth to water table	Consumptive use	Av. depth to water table	Consumptive use	Av. depth to water table	Consumptive use	Av. depth to water table	Consumptive use	Standard W.B. Pan	12-ft.-diameter pan
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1926											
April	-	-	-	-	-	-	-	-	-	6.28	4.14
May	0.78	-	-	28	1.84	-	-	-	-	10.41	7.20
June	0.06	36	1.50	21	1.81	-	-	40	1.16	14.44	9.63
July	0.54	39	4.20	36	2.46	-	-	40	2.50	13.82	9.09
August	0.42	32	6.67	28	6.67	-	5.42[2]	31	3.97	14.57	9.67
September	0.28	28	7.53	30	3.42	-	5.28[2]	24	4.53	11.84	8.12
October	0.20	31	4.59	41	0.80	-	1.20[2]	40	1.18	7.75	5.12
Annual	2.28	33	24.49	31	17.00	-	11.90	35	13.34	79.11	52.97
1927											
April	0.63	-	2.63	-	-	-	-	-	-	-	-
May	1.02	-	4.52	21	3.58	23	3.80	30	2.66	11.97	8.27
June	0.10	33	3.23	31	3.78	24	5.80	27	4.94	14.98	10.20
July	0.91	38	6.89	28	5.61	25	6.71	28	7.51	14.22	9.72
August	0.47	37	4.79	25	3.58	21	4.47	28	6.37	13.63	8.93
September	0.50	39	4.53	23	3.11	23	3.63	26	4.91	11.11	7.13
October	1.47	33	4.37	28	2.69	24	2.65	15	3.28	6.74	4.45
Annual	5.10	36	30.96	26	22.35	23	27.06	26	29.67	72.65	48.70

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[1] From U. S. Geological Survey Water-Supply Paper 659, by Walter N. White, 1932.

[2] Partially estimated.

Precipitation does furnish at least part of the water needs of the plants, whether irrigated or nonirrigated. Therefore, in preparing table 2, precipitation was added to the monthly use of underground water as reported by White. It is possible, of course, that part of the seasonal precipitation may have been lost by surface runoff, or even to the ground water. However, since the maximum rainfall occurring in any one month during the two seasons of White's study was less than 1.5 inches, it is questionable that any appreciable amount of precipitation was lost by either surface runoff or deep percolation.

DESCRIPTION OF STUDY

This study is an attempt to determine unit consumptive use rates and to inventory all water supplies and their uses within the Milford Valley.

INFLOW-OUTFLOW STREAMFLOW MEASUREMENTS

In order to obtain a water balance within the valley, all of the inflow and outflow must be taken into consideration together with the water used within the valley. In order to do this, the valley area lying between the Rockyford Dam gaging station and the gaging station near Milford on the Beaver River was used. The east and west boundary of the area ran along the edges of the uppermost irrigated land. During the early-spring runoff from snowmelt, and during periods of heavy rainfall, some small amount of unmeasured inflow would occur from the side drainages. However, the amount of unmeasured surface and underground inflow is considered to be minor.

All inflow and outflow measurements of the Beaver River were made using continuous recording gages by the Surface Water Division of the U. S. Geological Survey.

WEATHER DATA

Precipitation falling on the study area was measured at Minersville and Milford. Normally the Minersville station shows a greater catch than does Milford. Also, temporary rain gages were scattered throughout the valley. These temporary gages indicated rather wide variations in the rainfall throughout the valley. However, when annual precipitation is considered and not just individual storms, it appears that the average of the two regular Weather Bureau stations gives fairly good results for the valley as a whole.

Temperature was measured with maximum and minimum thermometers at Minersville and Milford. These data were also used to obtain the frost-free period or that period during which the temperature did not fall below 32° F.

Table 2.--Estimated annual consumptive use of water, Milford Area, 1926-27.[1]

Land class	Vegetation	Land area	Average depth to water table		Amount of water consumptively used annually			
			In the spring	In the fall	From ground water and irrigation water		Total use including ground water, irrigation, and precipitation[2]	
		Acres	Feet	Feet	Ac. in./ac.	Ac. ft.	Ac. in./ac.	Ac. ft.
A	Salt Grass	2,600	0 - 3	3 - 5	12.0	2,600	22	4,800
B	Greasewood, rabbit brush, and shad scale (Lowlands)	7,400	0 - 5	3 - 8	5.0	3,100	15	9,250
C	Greasewood, rabbit brush, and shad scale (Uplands)	18,000	8 - 30	8 - 30	2.0	3,000	12	18,000
D	Irrigated lands or naturally subirrigated cultivated lands	3,500	-	-	24.0	7,250	36	10,500
Total		31,500				15,950		42,550

[1] Adapted from U. S. Geological Survey Water-Supply Paper No. 659 by Walter N. White, 1932.

[2] Precipitation added, estimated at 10 inches.

Evaporation was measured from a standard Weather Bureau type pan located at the airport north of Milford. Because of its location away from the irrigated land, and because of the heavy wind movement at this point, evaporation from the pan may be greater than if it were down in the river bottom area.

Wind movement was measured by a totalizing anemometer from which the movement per day was computed for the various periods.

LAND-USE CLASSIFICATION

All of the land within the boundaries of the study area was mapped and classified according to crop, kind, and density of natural vegetation or water surface. In computing valley consumptive use, it was assumed that all irrigated cropland received adequate water for good growth. Standard values of water requirement were used for each crop.

Considerable portions of the mapped land received no irrigation water and the ground-water table was too low to contribute to the water requirements of the vegetation. All of the water used by such vegetation had to come from precipitation. Under this condition only scattered sagebrush and small spring grasses will survive. With more water available, either from ground water or irrigation, the natural vegetation became more dense and showed more vigorous growth.

Field work.

A land-use classification was made in the field about the first of September each year of the investigation. Aerial photos were used as a base with an acetate overlay. The field boundaries and classifications were written directly on the overlay. Since the photos were relatively new, only minor changes in field boundaries had occurred since the photographing. Classification could be made directly from a car for the most part. However, it was sometimes necessary that the classifier walk to some interior fields and check on field boundaries and what crop was being grown on the field. Where necessary, distances were checked by pacing. Chains or other surveying instruments were not used.

The major difficulty encountered in the field mapping was attempting to differentiate between meadowlands that were dry, medium wet, and wet. This land is materially affected by the available water supply which varied from year to year.

Office computations.

Tracings were made of the field sheets and the acreage of each land classification tabulated by sections. In order to correct for any map distortion, the computed areas for each section were adjusted so that the total area of the section was equal to the official area of that section. In general, the necessary corrections were small, seldom exceeding 0.5 percent, but each land class was adjusted accordingly.

SOIL-MOISTURE-DEPLETION STUDIES

From a number of selected fields, samples were taken periodically to determine the moisture content of the soil within the root zone of the crop. An attempt was made to sample just prior to the time of irrigation and as soon afterward as the free water had drained from the root zone or had distributed itself throughout the soil.

By analyzing the rates of depletion between sampling dates and interpolating over the periods in which irrigation or rainfall occurred, it was possible to determine the amounts of water used by the various crops. This procedure has been used rather widely in consumptive use studies throughout the West.

The fields chosen for study varied from year to year depending on their suitability for making the necessary measurements, the willingness of the farmer to participate, and the crops on which data were desired.

No measurements were made of water use by natural vegetation. Lands receiving precipitation as the only source of water comprised, however, some 80 percent of the nonarable land. With annual rainfall amounting to less than 10 inches and being rather well distributed throughout the year, and with the relatively low intensity storms that occur in the area, it was felt that practically all of the precipitation is absorbed by the soil and held within the root zone of the vegetation. Thus, for all practical purposes, all of the precipitation falling on the nonirrigated area mapped was considered as being used consumptively either by evaporation or transpiration.

QUANTITY OF WATER PUMPED FROM WELLS AND DIVERTED FROM THE RIVER

During 1953 and 1954, the U. S. Geological Survey Ground Water Division carried on an intensive study of the amount of water pumped from individual wells with the area served by the well. It appears that the amount of water applied in acre feet per acre is determined more by the capacity of the well and pump than by actual needs of the crops. Most of the wells are pumped continuously during a 5-month irrigation season, except during the crop harvest period when it is essential to get on the land. This condition is partly the result of the way electric-power billings are made, since there is little saving in power costs by shutting down for a short period of time.

GROUND-WATER CONTRIBUTION

The changes in depth to ground water were measured periodically. From depth to water table measurements made in December of each year, the volume of sediments that were either unwatered or submerged was determined.

Specific yield of water from the sediments must be determined or estimated in order to get the total contribution of ground water to valley consumptive use. Specific yield depends upon the kind of sediment in the aquifer and has been found, under extreme conditions, to vary from 10 to 30 percent of the total volume. An average figure of 20 percent was considered reasonable for this study.

WATER APPLICATION EFFICIENCIES

Some water application efficiency measurements were made within the valley during 1954. Fields were chosen, and all irrigation water applied to them and all surface runoff from them measured. Deep percolation was obtained indirectly. Consumptive use minus precipitation since the last irrigation was considered to be the amount of water that could be stored by an irrigation. The amount of water needed to refill the root zone of the crop to field capacity was subtracted from the amount of water absorbed. The difference was considered to be deep percolation.

DISCUSSIONS AND RESULTS

Most of the information gathered is the result of the studies which began in 1951 and continued through 1954. However, at the beginning of the investigation several items were not included for study which later appeared to be desirable and the study was changed accordingly. The results of the study follow.

WEATHER INFORMATION

For a number of years, the U. S. Weather Bureau has maintained weather stations at Minersville and Milford. The data gathered have included precipitation, temperature, and frost-free periods. These data and the long-time normals are given for 1951 to 1954 in tables 3 and 4. In 1953, an evaporation pan and animometer were added to the station at the Milford airport. The data for evaporation and wind movement in 1953 and 1954 are given in tables 5 and 6.

LAND-USE CLASSIFICATION

Land classification consisted of mapping the areas in the field and determining the acreage of each classification in the office.

The 1951 land-use surveys were conducted by different individuals than were the later classifications. Since classification of natural vegetation is somewhat a matter of judgment, some variation might be expected, if the mapping was done even in comparable water years. However, in the Milford-Minersville area, a large increase in irrigated cropland and a major decrease in fallow acreage did occur from 1951 to 1952. In addition, considerable acreage of new land was broken out of sagebrush and irrigated for the first time in 1952. Nineteen fifty-one was an unusually dry summer and much of the borderline land appeared to receive no seepage or surface flooding. The snow pack during the spring of 1952 and the resulting runoff was among the highest of record and considerable acreage received flood waters and seepage. As a result there is considerably more acreage

Table 3.--Mean monthly temperatures and frost-free periods at U. S. Weather Bureau Station, Milford, Utah, 1951-54.

Month	1951	1952	1953	1954	Normal
	°F.	°F.	°F.	°F.	°F.
January	26.8	24.4	37.6	30.9	23.8
February	32.9	28.4	29.7	35.4	30.9
March	36.9	34.3	40.4	36.7	39.2
April	48.3	48.3	46.2	51.6	47.8
May	56.9	58.1	50.3	59.4	56.8
June	64.5	65.3	65.9	64.8	65.8
July	75.4	73.7	76.6	75.5	74.0
August	71.3	74.8	71.3	70.1	71.7
September	64.1	64.4	65.6	63.6	62.6
October	48.8	54.9	49.1	51.3	50.1
November	34.5	32.5	41.8	39.2	37.4
December	22.7	30.7	23.4	28.0	28.0
Annual	48.6	49.1	49.8	50.6	49.0
Frost-free period	5/13-9/22	4/23-9/12	5/28-10/3	6/10-9/16	5/20-9/23
Days	132	142	128	98	126

Table 4.--Monthly precipitation in Milford Valley, Utah, for the period of study, 1951-54.

Month	1951			1952			1953			1954			Longtime normal		
	Milford	Minersville	Valley average	Milford	Minersville	Valley average	Milford	Minersville	Valley average	Milford	Minersville	Valley average	Milford	Minersville	Valley average
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Jan.	0.38	0.69	0.54	0.83	0.86	0.84	0.40	0.60	0.50	1.53	1.66	1.60	0.57	0.87	0.72
Feb.	0.42	0.36	0.39	0.74	0.48	0.61	0.77	1.63	1.20	0.20	0.24	0.22	0.71	0.93	0.82
Mar.	0.48	0.30	0.39	1.83	2.31	2.07	1.23	1.11	1.17	1.31	1.29	1.30	1.06	1.08	1.07
Apr.	1.63	1.19	1.41	0.76	0.99	0.88	1.02	1.62	1.32	0.43	0.06	0.24	0.76	0.89	0.82
May	1.58	1.61	1.60	0.71	0.70	0.70	0.46	0.51	0.48	1.10	1.33	1.22	0.74	0.75	0.74
June	T[1]	0.23	0.12	0.35	0.80	0.58	0.06	0.08	0.07	0.35	0.18	0.26	0.45	0.43	0.44
July	0.76	1.14	0.95	0.07	0.50	0.28	1.22	2.70	1.96	1.01	1.80	1.40	0.77	0.93	0.85
Aug.	1.06	3.23	2.14	1.22	0.85	1.04	0.03	0.67	0.35	1.04	0.54	0.79	0.81	0.84	0.82
Sept.	0.48	0.63	0.56	0.45	0.26	0.36	T[1]	0.00	0.00	0.55	1.20	0.88	0.40	0.59	0.50
Oct.	1.82	1.72	1.77	0.00	0.00	0.00	0.87	1.36	1.12	0.23	0.04	0.14	0.88	0.93	0.90
Nov.	0.76	1.09	0.92	0.32	0.64	0.48	0.13	0.02	0.08	0.67	1.15	0.91	0.54	0.79	0.67
Dec.	1.31	2.33[2]	1.82	0.44	0.45	0.44	0.38	0.50	0.44	0.56	0.56	0.56	0.75	0.85	0.81
Annual	10.68	13.52	12.10	7.72	8.84	8.28	6.57	10.80	8.66	8.98	10.05	9.52	8.44	9.88	9.16

[1] T = trace.

[2] Estimated.

Table 5.--Monthly evaporation from standard U. S. Weather Bureau evaporation pan, Milford, Utah, 1953-54.

Month	1953	1954	Two-year average
	Inches	Inches	Inches
April	-	9.29	-
May	-	12.13	-
June	16.57	13.32	14.94
July	15.61	15.35	15.43
August	15.25	15.17	15.21
September	11.28	10.74	11.01
October	5.98	6.61	6.30
November	-	2.58	-

Note: The evaporation pan, located at the airport north of the town of Milford and outside of the irrigated area, was not installed until June 1953 and was not read during freezing weather.

Table 6.--Total measured wind movement in miles per month at Milford, Utah, compared with other locations in Utah, 1953 and 1954.

Month	1953						1954					
	Location in Utah											
	Milford	Bear River Refuge	Fort Duchesne	Logan Agr. Expt. Sta.	Provo	Utah Lake	Milford	Bear River Refuge	Fort Duchesne	Logan Agr. Expt. Sta.	Provo	Utah Lake
	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Jan.	-	1,418	-	-	-	1,497	-	1,096	483	-	-	1,704
Feb.	-	1,815	-	-	-	2,301	-	1,257	1,069	-	-	1,862
Mar.	-	1,734	-	-	-	2,391	-	2,341	1,830	-	-	2,341
Apr.	-	1,954	-	1,643	2,298	2,742	3,924	2,217	1,943	1,602	-	3,051
May	-	1,966	1,533	1,547	2,368	2,968	3,791	2,021	-	1,065	-	2,996
June	4,530	1,759	1,426	1,002	1,781	2,712	3,627	2,154	1,040	1,236	1,339	2,934
July	3,760	1,491	806	581	1,213	1,856	3,604	1,672	547	926	1,262	2,296
Aug.	4,257	1,777	794	1,492	1,396	2,333	3,787	2,081	333	1,191	1,306	2,652
Sept.	2,665	1,021	746	740	941	1,180	3,224	1,699	255	870	1,279	2,444
Oct.	2,843	1,393	843	1,045	1,298	1,568	2,875	1,368	397	741	1,189	1,817
Nov.	-	1,253	560	-	1,210	1,618	613	1,087	-	-	-	1,612
Dec.	-	1,363	725	-	-	1,532	-	1,032	-	-	1,005	2,160
Annual	-	18,944	-	-	-	24,698	-	20,025	-	-	-	27,869

classified as wild hay or meadowland in 1952 than in 1951. Conditions in 1953 and 1954 were more nearly like 1951 than 1952.

A tabulation of the land classification for each year of the study is given in table 7.

STREAMFLOW

The only important source of surface inflow to the Milford Valley is the Beaver River (see figure 2, page 33). This river enters the south end of the valley through a narrow canyon east of Minersville. Rockyford Dam was constructed across this canyon in the early 1900's to control and store the natural flows of the river for use on the lands to the west and north of Minersville. A standard U. S. Geological Survey recording, stream gaging station is located a short distance downstream from the dam. This station has been in continuous operation since 1917.

At the mouth of the canyon, 3 miles below Rockyford Reservoir, the Minersville Canal diverts water from the river for irrigation of lands in the vicinity of Minersville and to the west of the town on the south side of the river channel. The other principal diversion is the Delta Land Canal, heading at the north edge of Minersville and extending northwest toward Milford. This latter canal irrigates a narrow strip of land adjacent to the river channel so that recharge to ground water from either the canal or the river would cover the same general area. Gaging stations were operated on the Minersville Canal, just east of Minersville, and on the Beaver River above the Delta Land Canal diversion to measure surface water available for irrigation. During normal water-supply years all of the flow passing this river gaging station is diverted by the Delta Land Canal. Other diversions are relatively small and were not measured during the investigation.

Comparative records collected by the Utah State Engineer's office in 1950 and earlier, show a small net gain in flow within the canyon section between the gaging station below Rockyford Dam and the heading of the Minersville Canal. However, records of total diversions and remaining supply in the river channel below the diversions show a large loss to ground water in the reach immediately downstream from the Minersville Canal heading. The gaging station below Rockyford Dam, therefore, records the surface-water inflow to the project.

The outflow from the valley is minor. Except for 1952, neglecting all of the outflow would have made little difference in the results (see table 8). This outflow station was installed by the U. S. Geological Survey in 1951. It is located about 4 miles west of Milford, where the valley is narrow. Because of the low gradient of the land surface and the tightness of the soils at the outflow station, very little underground flow is believed to occur.

The streamflow records show that the difference between inflow and outflow varied from about 14,000 acre feet in 1951 to nearly 40,000 acre feet in 1952. This streamflow depletion either was used consumptively or

Table 7.--Land-use classification for Milford - Minersville Area, 1951 to 1954.

Classification	1951	1952	1953	1954
	Acres	Acres	Acres	Acres
Irrigated cropland				
Alfalfa	4,900	5,364	7,550	7,721
Small grains	2,899	5,041	3,667	3,639
Corn	238	473	509	610
Grass pasture[1]	209	242	261	198
Wild hay or meadow (medium wet)	0	1,388	6	3
" " " " (wet)	77	145	35	0
Miscellaneous	773	1,905	2,609	2,310
Subtotal	9,096	14,558	14,637	14,481
Noncropped land				
Fallow	6,178	3,634	2,899	3,595
Roads and Farmsteads	708	553	360	377
Water Surface	33	6	6	168
Seeped areas	72	1,055	329	156
Subtotal	6,991	5,248	3,594	4,296
Native vegetation				
Very dense[2]	25	160[3]	160	141
Dense[4]	20	300[3]	324	326
Medium[5]	284	1,200[3]	1,367	1,201
Light[6]	3,333	3,000[3]	3,456	3,390
Sparse[7]	10,862	9,168[3]	10,538	11,819
Subtotal	14,524	13,828	15,845	16,877
TOTAL	30,611	33,634	34,076	35,654
Sparse added to balance with 1954	5,043	2,020	1,578	0
GRAND TOTAL	35,654	35,654	35,654	35,654

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[1] This classification assumes that all water received by the plants is from precipitation or surface irrigation with no high water table existing.

[2] Large cottonwoods, willow and grass.

[3] Partially estimated.

[4] Small cottonwoods and willows with grass.

[5] Scattered willows and heavy greasewood and sagebrush.

[6] Medium heavy greasewood and sagebrush.

[7] Scattered grass and brush receiving only precipitation.

Table 8.--Milford Valley streamflow measurements, 1951-54.[1]

1	2	3	4	5	6
Month	Location of gaging station				
	Beaver River below Rockyford Dam	Beaver River at Minersville	Minersville Canal near Minersville	Beaver River near Milford, outflow	Inflow minus outflow (col. 2-5)
	Ac.ft.	Ac.ft.	Ac.ft.	Ac.ft.	Ac.ft.
1951					
Jan.	310	210	100	0	310
Feb.	285	185	100	0	285
Mar.	361	261	100	0	361
Apr.	430	200	200	0	430
May	2,660	500	2,000	0	2,660
June	3,180	800	1,700	0	3,180
July	2,760	992	1,570	0	2,760
Aug.	2,200	643	1,560	0	2,200
Sept.	1,010	316	727	0	1,010
Oct.	275	141	128	0	275
Nov.	256	192	142	0	256
Dec.	280	214	81	9	271
Annual	14,007	4,654	8,408	9	13,998
1952[2]					
Jan.	326	221	73	48	278
Feb.	350	212	138	791	-441
Mar.	508	361	217	1,510	-1,002
Apr.	908	668	303	155	753
May	14,820	10,410	3,570	4,380	10,440
June	14,160	9,720	2,800	4,410	9,750
July	7,520	3,450	2,050	98	7,422
Aug.	6,580	2,680	2,010	97	6,483
Sept.	3,990	2,250	714	75	3,915
Oct.	1,170	480	132	1	1,169
Nov.	471	295	123	1	470
Dec.	502	357	118	18	484
Annual	51,305	31,104	12,248	11,584	39,721

Table 8. (Con't.)

1	2	3	4	5	6
	Location of gaging station				
Month	Beaver River below Rocky-ford Dam	Beaver River at Minersville	Minersville Canal near Minersville	Beaver River near Milford, outflow	Inflow minus outflow (col. 2-5)
	Ac. ft.	Ac. ft.	Ac. ft.	Ac. ft.	Ac. ft.
1953					
Jan.	621	531	114	34	587
Feb.	653	578	105	60	593
Mar.	785	767	43	85	700
Apr.	1,080	486	188	56	1,024
May	4,490	1,310	2,000	42	4,448
June	5,170	2,010	2,000	T[3]	5,170
July	5,760	2,300	1,830	14	5,146
Aug.	4,960	2,170	1,820	0	4,960
Sept.	1,280	575	507	0	1,280
Oct.	319	254	100	0	319
Nov.	307	210	95	0	307
Dec.	322	182	96	0	322
Annual	25,747	11,373	8,898	291	25,456
1954					
Jan.	340	235	105	14	326
Feb.	363	239	118	22	341
Mar.	498	340	113	42	456
Apr.	732	338	242	12	720
May	4,430	1,450	2,060	9	4,421
June	3,470	1,010	1,690	T	3,470
July	2,680	510	1,560	0	2,680
Aug.	2,600	571	1,840	0	2,600
Sept.	477	179	424	0	477
Oct.	246	156	108	0	246
Nov.	241	158	124	0	241
Dec.	265	175	93	0	265
Annual	16,342	5,361	8,477	99	16,243

[1] Table figures are partially estimated.

[2] 1952 streamflow is an exception to that of recent years.

[3] T = Trace.

went to replenish the ground water supply. Undoubtedly, there was considerably more contribution to ground water in 1952 than during years of lower streamflow volumes.

Most of the surface water supply available to the Milford Valley develops from the high mountain area east of Beaver. Records of the Beaver River above irrigation diversions east of Beaver are an excellent index of the surface water resources. It is significant to note that during the past 45 years, 5 of the 7 lowest years of record have occurred during the past 6 years. Only in 1952 was streamflow above average during recent years. Thus, the most sustained drought period for the past 45 years occurred during this investigation, and a return to normal has not yet been indicated.

GROUND WATER

The U. S. Geological Survey Ground Water Division and the State Engineer have been studying the Milford ground-water basin for a number of years. The results of previous ground-water studies in the Milford area, including present investigation to December 1953, have been published in the following reports of the State Engineer and are, therefore, not repeated in this report.[6]

Ground-water levels were relatively low from 1931 to 1935 but rose rather abruptly during 1936 and 1937 as a result of more favorable precipitation. Although there was some variation, water levels were relatively high until 1950, when a rapid decrease started which culminated in the lowest ground-water elevations of record. Thus, a sustained progressive decline in water levels occurred during the period of this investigation and a return to normal has not yet been indicated. It is important to note, however, that 41,300 acre feet was pumped for irrigation in 1953 and 38,600 acre feet in 1954. This is nearly three times as much as was pumped annually during the 1932-45 period.

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[6] "Ground Water in the Escalante Valley, Beaver, Iron, and Washington Counties, Utah" by Philip F. Fix et al., Utah Office of State Engineer Biennial Report (1948-50) 27: Tech. Pub. 6, 109-210, 1950.

"Status of Development of Selected Ground-Water Papers in Utah" by H. E. Thomas, Utah Office of State Engineer Biennial Report (1950-52) 28: Tech. Pub. 7, 111-206, 1952.

"Progress Report on Selected Ground-Water Basins in Utah," Utah Office of State Engineer Biennial Report (1952-54) 29: Tech. Pub. 9, 5-93 and 95-104, 1954.

Since climatic conditions in 1954 were not much different than in 1953 and water requirements should have been similar, it is interesting to note a field man's explanation of the decreased pumpage in 1954, which follows:

> "In 1954 a total of 38,610 acre feet of ground water was pumped to irrigate more than 9,200 acres of farmland in the Milford district. The rate of water use ranged from 1.2 acre feet to 9.2 acre feet per acre. This water was pumped from 136 irrigation wells, with yields ranging from 100 to more than 2,200 g. p. m. There was a decrease in the average use of water in the valley from 4.4 acre feet per acre in 1953 to 4.1 acre feet per acre in 1954.
>
> "Most of the wells in the Milford district discharged less water during 1954 than during the previous year. In general, wells were pumped at full capacity for about the same number of hours each year, but because of increased pumping lifts during 1954, less water was pumped. Notable exceptions to this trend were wells that were replaced during the second year by larger, more efficient pumping units. In these instances, as much as 50 percent more water was pumped in 1954 than in 1953. It is apparent from the data available that the rate of application of water, in acre feet per acre, is determined more by the capacity of the well and pump than by the actual needs of the crops. Few of the wells in the district are shut down during the 5-month irrigation season except during the harvesting of crops. This apparent over-application of irrigation water during periods of low demand is aggravated by the cost structure of the monthly power bill submitted by the local power company."

During 1951 and 1953, approximately the same amount of water was pumped each year. However, the 1951-52 winter and spring precipitation and resulting river runoff was greater than any of the other years under study. Undoubtedly, as a result of this heavy runoff, there was considerable contribution to the ground water. However, this contribution may not have been fully reflected in the ground-water measurements because of the lag in time necessary to get the water level stabilized. Perhaps the actual volume of stored water removed from the underground basin during 1953 was greater than indicated by the well measurements. A summary of the total amount of water pumped and the basin depletion is given in table 9.

CONSUMPTIVE USE BY CROPS AND NATURAL VEGETATION

Field measurements of consumptive use of water by the more important crops were made during each of the 4 years of study. There were no measurements made of use by natural vegetation. In 1951, when the study was first started, little was known about the soils or irrigation practices of the area. Moisture-depletion studies to determine consumptive use were

Table 9.--Summary of ground-water studies in Milford Valley by the U. S. Geological Survey, 1951-54.

Year	Amount of water pumped	Volume of sediments dewatered[1]	Volume of stored water removed[2]
	Acre feet	Acre feet	Acre feet
1951	32,200	41,000	8,200
1952	32,700	30,000	6,000
1953	41,300	66,000	13,200
1954	38,600	91,000	18,200
Average	38,200	57,000	11,400

[1] Determined from the change in elevation of ground-water levels and area affected. The change in levels is caused by a combination of pumping and natural recharge that takes place.

[2] Assumed to equal 20 percent of the volume of dewatered sediments.

limited and considered as being of secondary importance to other phases of the study. The same applies to a lesser degree in 1952. However, during the last 2 years of the investigation, 1953 and 1954, a more intensive study of this problem was made. Thus, it is felt that the earlier data, which in some cases vary rather widely from the 1953-54 results, should be considered as the less reliable.

Procedures used.

The methods of determining consumptive use on selected fields in the Milford Valley study have been used widely throughout the West and the procedure is considered more or less standard. In general, the method consists of periodically sampling the soil in the root zone anddetermining the withdrawal of moisture by the crop during the individual periods between sampling dates. During periods when rainfall or irrigation occurred, it was necessary to interpolate the amount of water consumptively used. The seasonal use is the summation of the uses during the various periods within the frost-free, or growing, period. Although the actual field procedures varied slightly from year to year, 1954 was typical of the process used and is described below.

Test fields were selected which were believed to have fairly uniform soils. For each location, a consistent pattern of soil sampling was established. Four samples were taken of each foot to a depth of 6 feet for alfalfa and 5 feet for all other crops. All sampling was done between 6 a. m. and 10 a. m. every 4 to 7 days.

Moisture content of the soil samples was determined in the laboratory by standard procedures. It was assumed that after irrigation all moisture removed below field capacity was consumptively used. Rainfall occurring between sampling dates was added to the measured change in moisture content of the soil. Any rainfall in excess of that needed to raise the water content of the soil profile to field capacity was neglected. The use rate during the periods of rainfall and irrigation was considered to be about average of those periods of measurement immediately preceeding and following the irrigation.

Most of the summer field work was carried on by graduate students who were not available early in the spring or late in the fall; consumptive use was partially estimated for the months of April, May, and October. However, the normal freezing dates are September 24 to May 19, so the amount of unmeasured consumptive use is not great. Probably a maximum of 20 percent of seasonal use was estimated for any single crop; usually, the estimated part represented a much smaller proportion.

Growing period.

Although the average length of the frost-free period at Milford (table 3) is only 126 days, or from May 20 to September 23, the actual growing period of perennial crops such as alfalfa is known to be longer and the crop must have water available throughout its entire growing period. Most perennials begin growing as soon as the maximum temperature stays well above freezing for a sustained period and usually continue to grow for some time after the first frost in the fall.

In the Milford study, it was assumed that, on an average for the 1951-54 period, growth of alfalfa started on April 15, or more than a month prior to the last frost on May 19. It was also assumed that growth continued for 189 days until October 24, or a month beyond the first fall frost on September 24.

After examining the temperature records in detail, it seems likely that during part of that extended growth period, evaporation from the land surface may have been the major consumptive loss of water. Until the end of April it was not uncommon to have minimum temperatures drop to or below 20° F. for several consecutive days in a row, which would have checked any real growth by the crop. A similar condition exists at the end of the growing period. In some of the irrigation water-requirement studies in the West, only the frost-free period has been of real concern, since normal spring and fall precipitation is more than adequate to take care of these pre-frost-free and post-frost-free uses.

Crop data.

The average measured consumptive use for crop and year of study is given in table 10. Seasonal use by corn, wheat, and other small grains was considerably higher in 1952 than in other years. It is believed that these data may include some water which normally would have gone to deep percolation. In other words, the sampling after irrigation took place before all of the free water had drained from the soil.

A similar condition probably existed with the potato studies in 1951. Irrigation and field samplings were so frequent that adequate drainage had not taken place at the time of sampling. For comparison purposes, results of consumptive use studies in other areas of the West are tabulated in table 11. These data tend to substantiate the earlier statement that the 1952 figures obtained in the Milford Valley may be somewhat out of line.

Natural vegetation data.

Measurements of use of water by natural vegetation were not a part of this study. However, not much area of natural vegetation is involved, and it is mainly classified as "light" and "sparse." The sparse category, which represents nearly one-third of the total mapped area of natural vegetation, is considered as using only the precipitation that falls on it. That mapped as "very dense" was given the highest use rate of all. It is estimated that about 5 percent more water is consumed by this classification per unit of area than evaporates from a free water surface. However, the area of land mapped as very dense is almost negligible.

Three classifications, "dense," "medium," and "light," were assigned use rates intermediate between those representing "very dense" and "sparse."

Table 10.--Measured consumptive use by soil-moisture-depletion method, Milford Valley, Utah, 1951-54.

Crop	Year	Growing season		Average consumptive use
		From--	To--	
				Inches
Alfalfa	1951	4/15	10/20	36.0
	1952	4/10	10/21	35.2
	1953	4/17	11/10	35.2
	1954	4/17	10/14	35.3
Corn	1951	6/1	9/10	22.0
	1952	5/15	9/12	26.5[1]
	1953	5/15	9/15	18.2
	1954	5/22	9/12	18.0
Sugar Beets	1953	5/31	10/15	25.6
	1954	5/7	10/14	27.1
Wheat	1952	5/2	8/21	29.0[1]
	1953	5/15	8/20	19.2
	1954	5/13	8/20	19.0
Other small grains	1951	5/15	8/15	17.0
	1952	5/2	8/21	28.7[1]
	1953	5/31	8/3	17.8
	1954	5/4	8/10	19.3
Potatoes	1951	6/15	10/1	21.0[2]

[1] Data out of line and appear to be in error, but perhaps these data include some deep percolation losses.

[2] Potatoes were irrigated so frequently that soil moisture was at or near field capacity much of the time. These data probably include considerable deep percolation.

Table 11.--Summary of measured seasonal consumptive use rates from various areas of the West.

Crop and location	Year	Growing season or period	Consumptive use of water	Reference[1]
Alfalfa				
Logan, Utah	1902-29	5/7-10/11	25.0	1
Carlsbad, N. Mex.	1940	4/18-11/10	38.6	2
San Fernando, Calif.	1940	4/1-10/31	37.4	3
Bonners Ferry, Idaho	1940-47	5/5-9/25	24.0	4
Vernal, Utah	1948-50	4/20-10/25	34.7	5
Ferron, Utah	1948-50	4/22-10/23	33.8	5
Redfield, S. Dakota	1950-53	-----	22.2	11
Logan, Utah	1949-55	-----	20.7	6
Corn				
Logan, Utah	1902-29	6/1-9/30	25.0	1
Vernal, Utah	1948-50	5/26-9/28	19.3	5
Ferron, Utah	1949-50	5/12-9/14	21.0	5
Arapahoe, Nebraska	1950	6/14-10/28	20.0	7
Redfield, S. Dakota	1951-53	-----	16.6	11
Potatoes				
Logan, Utah	1902-29	5/20-9/15	15.0	1
Logan, Utah	1949-55	-----	18.2	6
Scottsbluff, Nebraska	1932-35	6/20-9/30	15.4	8
Ontario, Oregon	1941-42	4/20-8/31	17.9	9
Prosser, Washington	1948	6/18-9/28	18.6	10
Redfield, S. Dakota	1950-53	5/12-9/12	15.7	11
Aberdeen, Idaho	1952-53	-----	10.9	12
Bowbells, N. Dakota	1951	-----	11.8	13
Sugar Beets				
Logan, Utah	1902-29	4/15-10/15	25.0	1
Scottsbluff, Nebraska	1932-36	4/20-10/15	24.0	7
Spanish Fork, Utah	1938	4/15-10/15	22.8	14
Huntley, Montana	1951	4/22-9/26	28.3	15
Logan, Utah	1949-55	5/1-10/5	21.4	6
Redfield, S. Dakota	1951-53	-----	24.0	11
Wheat				
Logan, Utah	1902-29	5/10-8/10	17.5	1
Bonners Ferry, Idaho	1930-47	5/5-8/5	17.5	4
Scottsbluff, Nebraska	1932-35	4/20-7/25	14.7	8
Prosser, Washington	1944	3/20-7/16	18.0	10
Vernal, Utah	1948-50	4/26-8/20	21.2	5
Ferron, Utah	1948-50	4/23-8/23	23.4	5
Redfield, S. Dakota	1953	-----	16.3	11

[1] Numbers refer to references in Supplement to table, pp. 29-30.

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Annual evapo-transpiration rates for water surfaces, and seeped areas and for native vegetation, except that classed as sparse, were not considered to vary from year to year, depending upon the climatic conditions, as were all other unit values of consumptive use. It was assumed that variations in use between years were small with little basis on which to establish such variations.

IRRIGATION EFFICIENCIES IN MILFORD VALLEY

During a normal irrigation, part of the water applied to a field is stored in the root zone of the crop, some is lost to deep percolation, and some may be lost as surface runoff from the field. A small amount is lost by evaporation from the water surface during irrigation but this is usually not considered important. The amount lost to each of the first three is dependent upon soils, topography, care given to the water, and many other factors.

The soils of the Milford Valley are fairly permeable and conditions are favorable for a considerable loss of water to deep percolation. The irrigation supply is obtained, to a large part, from ground-water sources. Deep percolation probably returns to the ground-water supply. Thus, except for the leaching of soil nutrients and fertilizer applied, and the added cost of power with excess application, deep percolation may not be too objectionable. The total basin water resource is not depleted because of deep percolation.

With surface runoff, the loss from the basin's supply may be considerable. Surface waste water usually collects in borrowpits or other low spots. Silt eroded from the fields causes sealing of the land surface and slow percolation into the soil. This allows heavy evaporation from these water surfaces and high rates of transpiration by vegetation growing in and around the wet areas. Thus, noneconomic consumption takes place which depletes the total supply of the basin. For economy in pumping and use of water, irrigation efficiencies should be held as high as practicable.

Effect of water cost on irrigation efficiency.

Water costs in most of the State of Utah are not high in comparison to other costs of production. For instance, average irrigation water and drainage costs for producing potatoes in the State of Utah are less than 2½ percent of the total cost of production.[7] Water costs are slightly higher in the more arid southern part of the State than in the north. Even in the south water costs do not generally exceed about 3 percent of production costs.

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[7] "Profit in Potatoes" by E. M. Morrison and W. G. Kearl. Farm and Home Science (Utah Agricultural Experiment Station) 16:25, 40-41, June 1955.

Although water cost figures are not available for the Milford area, data from the somewhat similar Iron County pump area give an average of about $12 per acre for water, including power, interest on capital investment, repairs, and depreciation. This is slightly more than 5 percent of the total production cost of potatoes. The labor for applying the water averaged another $12 per acre, or another 5 percent.

With the direct costs of water representing such a small part of the production costs, there is a tendency to overlook this item, especially if there is a possibility of saving some labor with excess use of water. Too often, these direct costs are the only ones considered by the individual farmer. Indirect costs such as leaching of plant nutrients, flooding of borrowpits with resultant road damage, production of mosquitoes, spread of weed seed, and the waste of the basin's water resource may be of much greater economic importance than are the direct costs.

Milford Valley studies.

During 1954, fields were chosen in the Milford Valley on which to study irrigation efficiency. Fields had to be chosen on which all irrigation water flowing to the field and all surface waste from the field could be measured. The general locations of the study fields are shown in figure 2. Most of the fields chosen for study of irrigation efficiency were also studies from the consumptive use standpoint.

Individual fields with representative crops and surface conditions were chosen. Each farmer would notify the field engineer of the intended time of irrigation. The engineer would try to be at the field before irrigation began.

The U. S. Geological Survey Ground Water Division periodically measured well discharges throughout the season. A record was kept of the time that each pump was operating. From these data the total amount of water applied during the season was computed.

If the well were located any appreciable distance away from the field, inflow to it was measured with portable weirs. In those few cases where stream size varied during an irrigation, periodic measurements of flow were made and average values used. When the well and pump were near the field being irrigated, the actual pump discharge was used. In general, the stream was measured at or near the head of the field being irrigated so that conveyance losses in getting the water to the field were negligible.

Surface waste from the fields was measured using rectangular weirs or small Parshall flumes. In some cases the actual volume of water flowing from the field was difficult to obtain. On a few fields where outflow could not be measured satisfactorily, furrow intake rates for typical furrows were measured and these data used to estimate the surface runoff. Since outflow was generally small as compared to inflow, it is felt that the error resulting from such a procedure is not great.

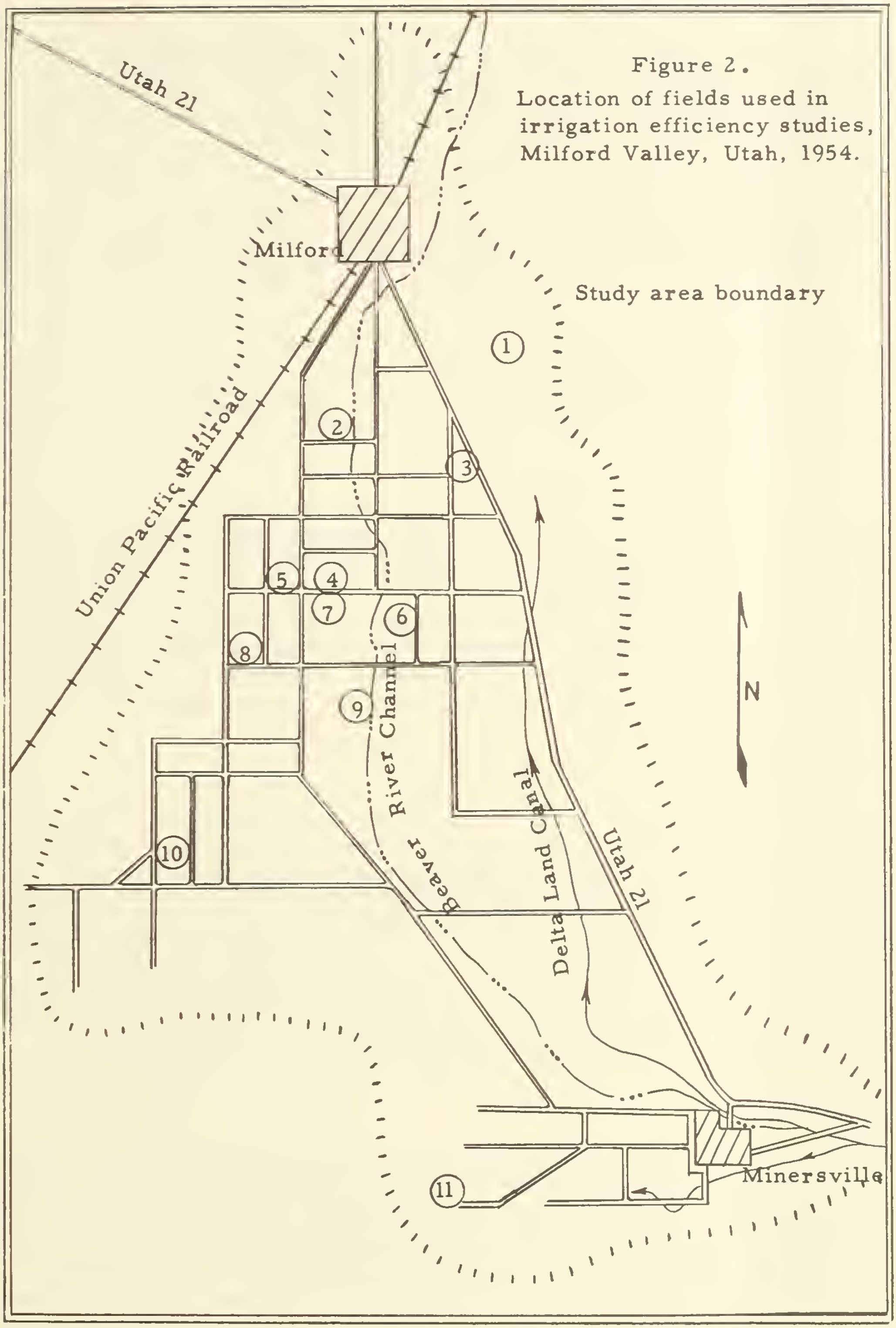

Figure 2. Location of fields used in irrigation efficiency studies, Milford Valley, Utah, 1954.

Water stored each irrigation.

Because of the great amount of time and labor involved in soil moisture sampling to measure the water stored in the soil each irrigation, an indirect method was used. All of the water applied to the fields and that flowing from the fields was measured. The difference was stored in the soil for use by the crop or lost as deep percolation. The amount stored in the soil was considered to be the amount of water consumptively used since the previous irrigation minus the precipitation that fell during the period. Consumptive uses during the period were either measured data from the companion consumptive use study if available or they were computed.

Unfortunately, irrigation efficiency for the first irrigation of the season was not measured because of lack of field personnel. However, except for this first irrigation most of the other applications made on the test fields during 1954 were measured. A summary of the results is given in table 12.

In general, irrigation efficiencies were highest on those fields receiving the least water. All received adequate water to meet the consumptive needs of the crops. With respect to alfalfa, only about 1 3/4 acre feet per acre was needed to meet the consumptive needs of the crop. The one field on which the highest efficiency was obtained, 67 percent, received only 2.14 feet depth of water and produced about 5 tons of hay per acre. The field with the lowest efficiency, 16 percent, received nearly 12 feet of water and produced only 4.5 tons of hay per acre.

VALLEY CONSUMPTIVE USE

Valley consumptive use is the amount of water used in all ways within a valley. Several methods have been developed for determining valley use. One, the "Inflow-outflow" method, measures all water entering and leaving the valley including precipitation and changes in ground-water storage. Another, the "Integration method," is to multiply the unit use by each crop or other land classification by the area in each classification. The sum of the products of the unit uses times the areas gives the total valley use. Still other methods estimate total valley consumptive use based on climatic data and empirical relationships with other valleys.

Inflow-outflow method.

Measuring all of the flow to and from an area is practically impossible under most field conditions. This would involve measuring all surface and ground-water flow. In an extremely tight basin, this might be reasonably approximated. It is believed that the Milford Valley is fairly well adapted to this method. The land contained within the general boundaries of the mapped area is not completely isolated from the surrounding lands and it is recognized that some ground-water inflow may take place from the southwest particularly. However, the slope of the land toward the north is relatively

Table 12.--Summary of water application efficiency tests, Milford Valley, Utah, 1954.

Field No.	Irrigation water applied	Computed[1] consumptive use minus rainfall during test period	Surface runoff of irrigation water		Deep percolation of irrigation water		Average irrigation efficiency for test period	Yield (estimated)
			Amount	Part of that applied	Amount	Part of that applied		
	Ac.Ft/ac.	Ac.Ft./ac.	Ac.Ft/ac.	Percent	Ac.Ft/ac.	Percent	Percent	Tons or bu/ac.
ALFALFA								
6-A	4.64[2]	1.96	0.23	5	2.36	51	44	5.0
4-A	11.83[3]	1.89	T[4]	0	9.95	84	16	4.5
11-A	3.62[2]	1.77	0.77	21	1.08	30	49	6.3
7-A	3.24[2]	1.63	0.16	5	1.45	45	50	4.5
9-A	2.14[2]	1.52	0.26	12	0.45	21	67	5.1
8-A	4.53[2]	1.73	0.10	2	2.76	61	63	4.5
5-A	5.30	1.33	0.00	0	3.96	75	23	4.5
POTATOES								
9-P	3.15[2]	1.21	0.56	18	1.36	43	39	-
2-P	2.66	0.96	0.10	4	1.60	60	36	-
CORN								
5-C	5.38[2]	1.22	0.00	0	4.07	76	24	(Frozen)
11-C	3.15[2]	1.31	0.62	20	1.32	42	28	12.0
SUGAR BEETS								
7-S	2.43[2]	1.22	0.21	9	1.21	50	42	-
3-S	1.39[2]	1.31	0.37	27	0.11	8	66	-

(See footnotes at end of table.)

Table 12. Summary of water application efficiency tests, Milford Valley, Utah, 1954--Continued.

Field No.	Irrigation water applied	Computed[1] consumptive use minus rainfall during test period	Surface runoff of irrigation water		Deep percolation of irrigation water		Average irrigation efficiency for test period	Yield (estimated)
			Amount	Part of that applied	Amount	Part of that applied		
	Ac.Ft./ac.	Ac.Ft./ac.	Ac.Ft/ac.	Percent	Ac.Ft/ac.	Percent	Percent	Tons or bu/ac.
BARLEY								
4-B	3.17[2]	1.07	0.00	0	2.10	66	34	88
8-B	1.62[2]	1.08	0.34	21	0.30	18	61	50
11-B	1.63[2]	0.82	0.25	15	0.56	34	50	95
WHEAT								
8-W	1.98[2]	1.05	0.61	30	0.56	28	41	36
1-W	1.34[3]	1.01	0.03	2	0.57	42	55	36
OATS								
5-0	1.25[2]	1.00	0.00	0	0.39	31	69	1.4

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[1] Consumptive use figure computed by Blaney-Criddle method for only the period of the efficiency study on each farm. It does not include that water consumed prior to the first irrigation nor following the last and is for different periods of time, since not all irrigations were made simultaneously.

[2] First irrigation of season not measured.

[3] First and second irrigations not measured.

[4] T = trace.

flat. There is no material movement of ground-water supply. Therefore, it is felt that the amount of underground recharge to the valley is small. Presumably most, if not all, of the water entering the valley from the upper Beaver River is forced to the surface at the Rockyford Dam site, and the gaging station at that point measures it with reasonable accuracy. Also, because of the nature of the sediments at the lower end of the valley, it is believed that unmeasured outflow is not appreciable. Surface inflow and outflow are shown in the hydrograph, figure 3. Table 13 gives the computed valley consumptive use by the inflow-outflow method.

Integration method.

Actual measurements of consumptive use of water by the soil-moisture-depletion-method include only that used during the growing period. In areas of light precipitation, such as occurs in the Milford Valley, it is reasonably safe to assume that most, if not all, of the precipitation falling during the winter period is consumed by evapo-transpiration from the land surface. Thus, annual consumptive use rates for the Milford Valley were computed by adding to the measured summer use, the winter precipitation on the crops studied in the valley. These computations appear in table 14. Measured values of summer use were used in all cases except three which appear to be out of line. On this basis, annual use of water by alfalfa varied from a low of 38.6 inches depth in 1953 to 40.1 inches in 1952. These values seem to be in line with rates of annual use in other areas of similar climatic conditions.

Using the values of annual consumptive use from table 14, evaporation data, and consumptive use of water information from other areas, unit values of annual consumptive use were established for each land class mapped. These annual values multiplied by the land-class area give the total valley use, as shown in table 15. Although these values show some variation from year to year, the average of 65,075 acre feet is not too far away from the average value arrived at by the inflow-outflow method of 64,298 acre feet. Perhaps a round figure of 64,500 acre feet per year would be a reasonable value to use.

EFFECT OF CONSUMPTIVE USE ON WATER RESOURCES

In a climate such as that of the Milford Valley, consumptive use of water by vegetation varies widely from year to year where rainfall is the only source of water. In general, all precipitation falling onto the valley lands is consumed where it falls. Thus, consumptive uses on nonirrigated lands are directly correlated with precipitation.

All adequately irrigated land of the valley consumes water independently of precipitation. This is also more or less true of use of water by natural vegetation along the streams or where water in addition to rainfall is obtained directly from ground-water sources by the plants. Whether the land is irrigated or nonirrigated, practically all precipitation falling on the Milford Valley floor is considered as being consumed where it falls.

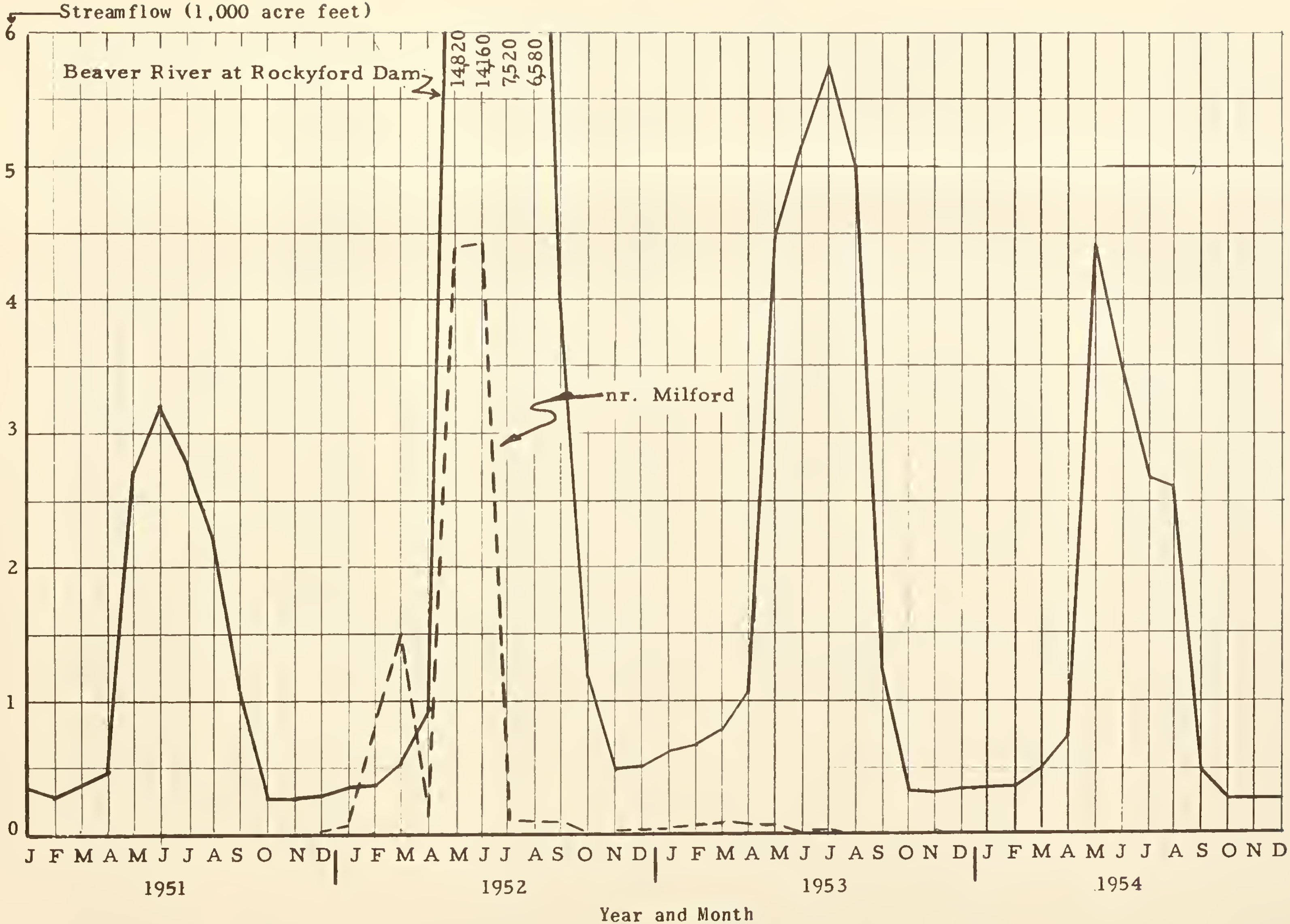


Figure 3. Monthly Streamflow at Beaver River Gaging Stations.

Table 13.--Annual consumptive use computed in the Milford Valley from inflow-outflow data, 1951-54.

Item	1951	1952	1953	1954	Average
	Acre ft.	Acre ft.	Acre ft.	Acre ft.	Acre ft.
Inflow					
Precipitation on mapped lands	35,939	24,601	25,928	28,167	28,659
Beaver River at Rockyford Dam	14,007	51,305	25,747	16,342	26,850
Change in ground-water storage	8,200	6,000	13,200	18,200	11,400
Inflow from side drainages	0	1,540	0	0	0
Underground inflow	negligible				385
Total inflow	58,146	83,446	64,875	62,709	67,294
Outflow					
Beaver River near Milford	9	11,584	291	99	2,996
Underground outflow	negligible				0
Total outflow	9	11,584	291	99	2,996
Valley Consumptive Use (Inflow-outflow)	58,137	71,862	64,584	62,610	64,298

Table 14.--Computation of annual consumptive use rates of crops in Milford Valley, 1951-54.

Crop	Year	Measured consumptive use			Winter rainfall considered consumed				Total annual consumptive use
		Growing season From--	To--	Depth	Period From--	To--	Depth	Total depth	
				Inches			Inches	Inches	Inches
Alfalfa	1951	4/15	10/20	36.0	1/1 10/21	4/14 12/31	1.48 2.30	3.78	39.8
	1952	4/10	10/21	35.2	1/1 10/22	4/9 12/31	4.02 0.92	4.94	40.1
	1953	4/17	11/10	35.2	1/1 11/11	4/16 12/31	2.89 0.50	3.39	38.6
	1954	4/17	10/14	35.3	1/1 10/15	4/16 12/31	3.12 1.58	4.70	40.0
Corn	1951	6/1	9/10	22.0	1/1 9/11	5/31 12/31	4.32 3.87	8.19	30.9
	1952	5/15	9/12	26.5 (Use 22)	1/1 9/13	5/14 12/31	4.40 1.28	5.68	27.7
	1953	5/15	9/15	19.6	1/1 9/16	5/14 12/31	4.56 1.63	6.19	25.8
	1954	5/22	9/12	18.0	1/1 9/13	5/21 12/31	1.58 2.06	3.64	21.6
Wheat	1951	-	-	-	-	-	-	-	-
	1952	5/2	8/21	29.0 (Use 21)	1/1 8/22	5/1 12/31	4.40 1.52	5.92	26.9
	1953	5/15	8/20	20.8	1/1 8/21	5/14 12/31	4.56 1.78	6.34	27.1
	1954	5/13	8/20	19.0	1/1 8/21	5/12 12/31	1.58 1.60	3.18	22.2
Other small grains	1951	5/15	8/15	17.0	1/1 8/16	5/14 12/31	3.52 6.63	9.15	26.2
	1952	5/2	8/21	28.7 (Use 21)	1/1 8/22	5/1 12/31	4.40 1.52	5.92	26.9
	1953	5/31	8/3	17.8	1/1 8/4	5/30 12/31	4.67 1.82	6.49	24.3
	1954	5/4	8/10	19.3	1/1 8/11	5/3 12/31	3.51 3.04	6.55	25.8
Sugar beets	1951	-	-	-	-	-	-	-	31.0[1]
	1952	-	-	-	-	-	-	-	31.0[1]
	1953	5/31	10/15	25.6	1/1 10/16	5/30 12/31	4.67 1.48	6.15	31.8
	1954	5/7	10/14	27.1	1/1 10/15	5/6 12/31	1.58 1.58	3.16	30.3

[1] Estimated.

Table 15.--Annual consumptive use of water in the Milford Valley computed by the integration method, 1951-54.

Crops and other land use	1951			1952			1953			1954		
	Annual unit c. use rate	Area	Annual valley consumptive use	Annual unit c. use rate	Area	Annual valley consumptive use	Annual unit c. use rate	Area	Annual valley consumptive use	Annual unit c.use rate	Area	Annual valley consumptive use
	A.f./ac.	Acres	A.f.	A.f./ac.	Acres	A.f.	A.f./ac.	Acres	A.f.	A.f./ac.	Acres	A.f.
Cropped Land												
Alfalfa	3.32	4,900	16,268	3.34	5,364	17,916	3.22	7,550	24,311	3.33	7,721	25,711
Small grains	2.18	2,899	6,320	2.24	5,041	11,292	2.15	3,667	7,884	2.00	3,639	7,278
Corn	2.57	238	612	2.31	473	1,093	2.15	509	1,094	1.80	610	1,098
Grass pasture	2.95	209	617	2.95	242	714	2.90	261	757	2.95	198	584
Wild hay or meadow (wet)	3.50	77	270	3.50	145	508	3.50	35	122	3.50	0	0
Wild hay or meadow (med wet)	3.25	0	0	3.25	1,388	4,511	3.25	6	20	3.25	3	10
Miscellaneous	2.50	773	1,932	2.50	1,905	4,762	2.50	2,609	6,522	2.50	2,310	5,775
Subtotal		9,096	26,019		14,558	40,796		14,637	40,710		14,481	40,456
Noncropped Land												
Fallow	1.01	6,178	6,240	0.69	3,634	2,507	0.72	2,899	2,087	0.79	3,595	2,840
Roads & Farmsteads	1.01	708	715	0.69	553	382	0.72	360	259	0.79	377	298
Water Surface	5.00	33	165	5.00	6	30	5.00	6	30	5.00	168	840
Seeped Areas	4.00	72	288	4.00	1,055	4,220	4.00	329	1,316	4.00	156	624
Subtotal		6,991	7,408		5,248	7,139		3,594	3,692		4,296	4,602
Native Vegetation												
Very dense	4.50	25	112	4.50	160	720	4.50	160	720	4.50	141	634
Dense	3.75	20	75	3.75	300	1,125	3.75	324	1,215	3.75	326	1,222
Medium	3.00	284	852	3.00	1,200	3,600	3.00	1,367	4,101	3.00	1,201	3,603
Light	2.25	3,333	7,499	2.25	3,000	6,750	2.25	3,456	7,776	2.25	3,390	7,628
Sparse	1.01	15,905	16,064	0.69	11,188	7,720	0.72	12,116	8,724	0.79	11,819	9,337
Subtotal		19,567	24,692		15,848	19,915		17,423	22,536		16,877	22,424
TOTAL		35,654	58,029		35,654	67,850		35,654	66,938		35,654	67,482

The annual consumptive use rates in the cases of alfalfa, small grains, and corn is the measured consumptive use from field tests. (See table 14.) The figures for fallow, roads and farmsteads, and sparse vegetation are equal to the annual precipitation while all other figures are constants for the particular land use based to some degree on use of water by alfalfa and evaporation rates.

Annual consumptive use of water by agricultural crops is more nearly constant from year to year. When valley precipitation is below normal, the deficiency is made up by irrigation. The irrigation water comes either from surface streamflow or from the ground-water basin beneath the valley lands. When precipitation is below normal in the valley, the fall on the tributary watershed also is usually below normal and streamflow is low. Thus, waters coming into the valley for irrigation and ground-water recharge are less than normal. Since irrigation requires a fairly constant supply each year, during years of deficient precipitation more water is taken from underground. These are the years of greatest lowering of the ground-water table in the basin.

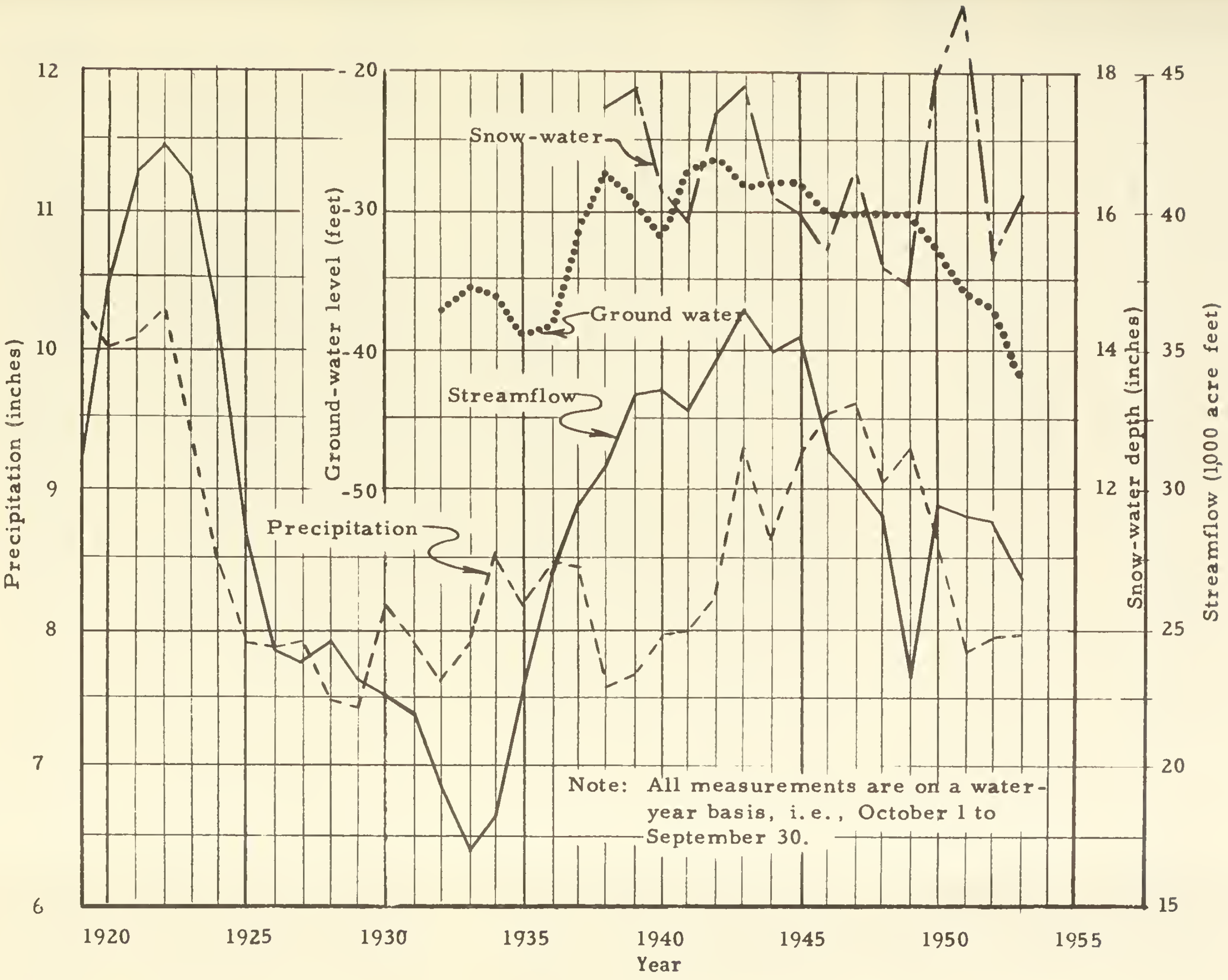
This condition existed in 1951, 1953, and 1954. In 1952, precipitation and resultant streamflow were high. Although there was a continual downward trend of the water table in the basin, the net withdrawal from the underground basin during 1952 was less. Also, it is believed that an underground wave of ground-water recharge may have resulted from the heavy runoff in the Beaver River in 1952. This incoming water may not have shown up in the measured wells during 1952. The network of observation wells are so located that they indicate ground-water levels under the main pumping area. They do not fully cover the extensive area needed to tell if additional water were headed toward the main cone of depression of the water table.

It is felt that recharge during 1952 and resultant rise of the water table was somewhat masked. Part of the apparent recharge in 1953 was actually creditable to 1952.

In 1908, when Willis T. Lee wrote of the swampy conditions of the Beaver Valley around Beaver and Milford (see footnote 3, p. 6), annual consumptive use of water in the valley may have been almost as much as it is today. However, based on Modena records, 1908 was in a period of high precipitation. The average annual precipitation for the 4-year period 1905 to 1908 was about 150 percent of the present normal of 10.73 inches. Presumably this same condition of high precipitation also occurred at the headwaters of the Beaver River watershed.

At the time of White's investigations in 1926-27, only a small part of the presently irrigated lands had been brought under irrigation. Although the outflow was not measured, it is possible that at that time there was somewhat greater flow out of the valley than now. However, it is believed that consumption of water within the valley has not changed much. Greater areas of wet lands and a higher water table may have allowed total evapo-transpiration losses to be almost as great as those of the present time.

Unusually low precipitation has occurred during the past several years as indicated in figure 4. The ground-water trend also has been downward in the Milford Valley, with an average of 11,400 acre feet being removed from underground storage for each year of the 4 years of the investigation.



Note: All measurements are on a water-year basis, i.e., October 1 to September 30.

Figure 4. Five-year moving average of annual Beaver River streamflow, valley precipitation, and snow-water depths and average annual depth to ground water, Milford Valley, Utah.

Both valley precipitation and Beaver River flow have also been low during this period. Not all of the available water has gone for agricultural purposes though. Even with the dropping water table, an average of nearly 12,000 acre feet was consumed annually by noneconomic vegetation and other uses that had more water available than just precipitation. Of this amount, some 7,000 acre feet might be salvaged simply by further lowering the water table and limiting use of water by these lands to precipitation only. Also, for the 4-year period, an average of about 3,000 acre feet (nearly all of which occurred in 1952) was lost as outflow from the valley. With adequate water spreading grounds, much of this water might have been captured and used to recharge the basin. Thus, upwards of 10,000 acre feet per year might be salvaged from present uses and losses for agricultural purposes. To make this saving would require (1) lowering the ground-water table beyond the reach of the phreatophytic vegetation, much of which grows outside the main pumping area, and (2) development and utilization of flood-water spreading grounds.

Additional water might be made available for the Milford Valley through drainage and reduction of water consumption on lands above Rockyford Dam. Such improvements would greatly benefit the presently wet lands in the Beaver Valley. At the same time, the usable water supply of the river system would be increased.

When plotted as in figure 4, streamflow of the Beaver River below Rockyford Dam, precipitation at Milford, ground-water levels in the Milford Valley wells and snow-water depths at Merchant's Valley, Otter Lake, and Big Flat snow courses, all show the same general trend. Each indicates that the valley may be experiencing an unusually low period in the water cycle.

CONCLUSIONS

1. Milford Valley has been experiencing a long drought period as indicated by precipitation, ground-water level, snow-water depths and streamflow records. There is no reliable way of telling if or when this trend will change. During individual years such as 1952 runoff has been heavy, but there have been no sustained series of years needed to reverse the downward trend of the ground-water levels which began in the early 1950's. It is interesting to note that the water levels in the key wells in the middle 1930's were about as low as they were during the 1951-54 study period.

2. The apparent annual overdraft of water from the basin during 1951 to 1954 period averaged some 11,400 acre feet. However, upward of 10,000 acre feet per year might be salvaged through further lowering the water table in certain areas and by capturing flood waters and using them to recharge the basin.

3. Average annual consumptive use within the valley study area was about 64,500 acre feet. Using the inflow-outflow method, consumptive use

was estimated to be about 64,000 acre feet per year. The integration method gave an estimate of some 65,000 acre feet per year, or a difference of less than 2 percent.

4. Of the 64,500 acre feet of water consumed annually, some 28,600 acre feet, or 44 percent, was obtained directly from precipitation falling on the area. Thus, only 35,900 acre feet had to come from surface- and ground-water sources.

5. The annual consumption of water on 17,300 acres of cropped plus fallow land was 40,600 acre feet, or an average of 2.35 acre feet per acre. However, an average of 13,900 acre feet came from precipitation falling on the area, leaving only 26,700 acre feet per acre used from irrigation.

   On any irrigated project all of the farm land is never cropped and irrigated any one year. There is always 10 to 15 percent or more of the farm area devoted to roadways, stackyards, farmsteads and wasted areas as well as certain areas of fallow or other noncropped lands.

6. From the standpoint of a basin resource, in areas such as the Milford Valley, loss of water through low irrigation efficiencies may or may not be serious. Much of the deep percolation returns to the underground basin. For the individual farmer who has to pay the pumping costs and maintain a high fertility level in his soil, such a loss is serious and expensive.

   Water lost by surface runoff which evaporates or goes to feed noneconomic vegetation depletes the basin's supply. Consumption of water by such evaporation and transpiration is just as effective in decreasing the overall supply as is consumption by crops.

7. Even in areas such as the Milford pumping district, water costs represent only a small proportion of the total cost of crop production. This is one major reason why low efficiencies are tolerated by some farmers in the valley.

8. Wind movement in the Milford Valley is rapid at times. However, wind may have less effect on consumptive use than has been generally believed in the past. Consumptive use of water by crops and other vegetation is a phenomenon different from evaporation from a free-water surface where loss of water is greatly influenced by the wind movement.

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